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UK CL (Edition N) **H1Q QDH, H4L LCL**
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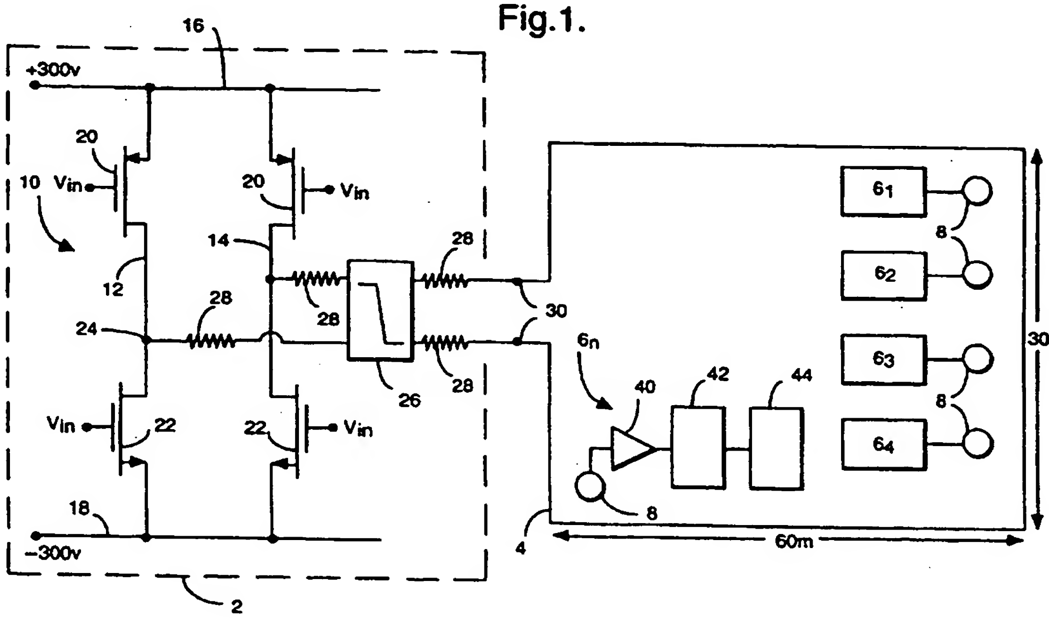
(54) **Data Communication System**

(57) A system for communicating over a local area (e.g. within a single building) comprises an inductive loop antenna (4) driven by a transmitter (2) having a resistive output impedance which is substantially (e.g. ten times) greater than the inductive impedance of the loop antenna over the range of frequencies (0-500kHz) transmitted. A bandwidth of 10kHz is achieved without significant change in the frequency response and consequent degradation in the signal quality. The loop antenna can also be short circuited or loaded into a sufficiently small resistance to achieve a flat frequency response in reception. A method is described of transmitting video signals by compressing and decompressing them.

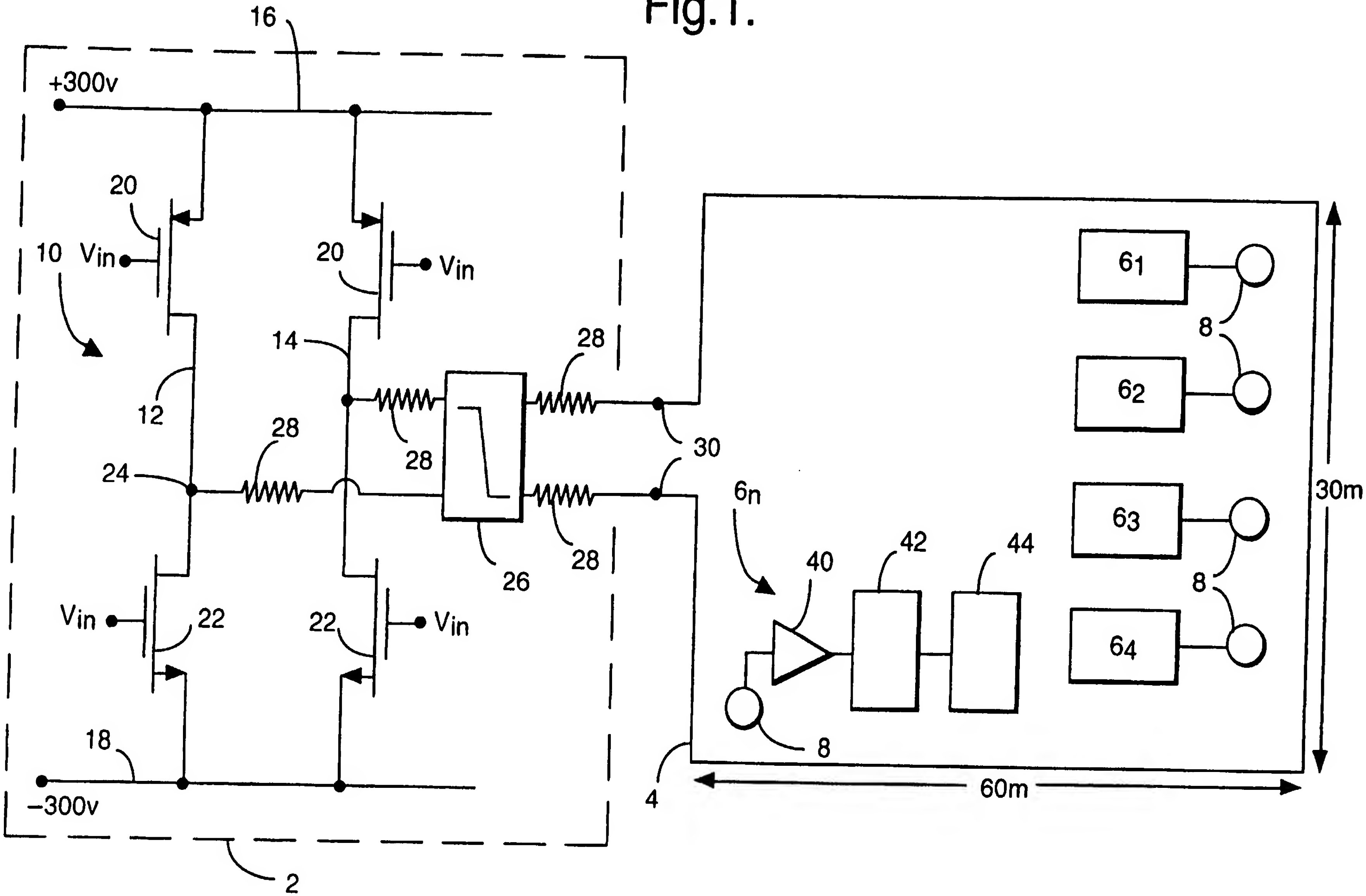
Fig.1.



GB 2 311 190 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.


16
+300v
20
10
Vin
20
Vin
14
28
12
28
28
24
26
28
30
30
6n
Vin
22
22
Vin
40
42
44
18
−300v
8
4
2
61
62
63
64
8
8
30m
60m

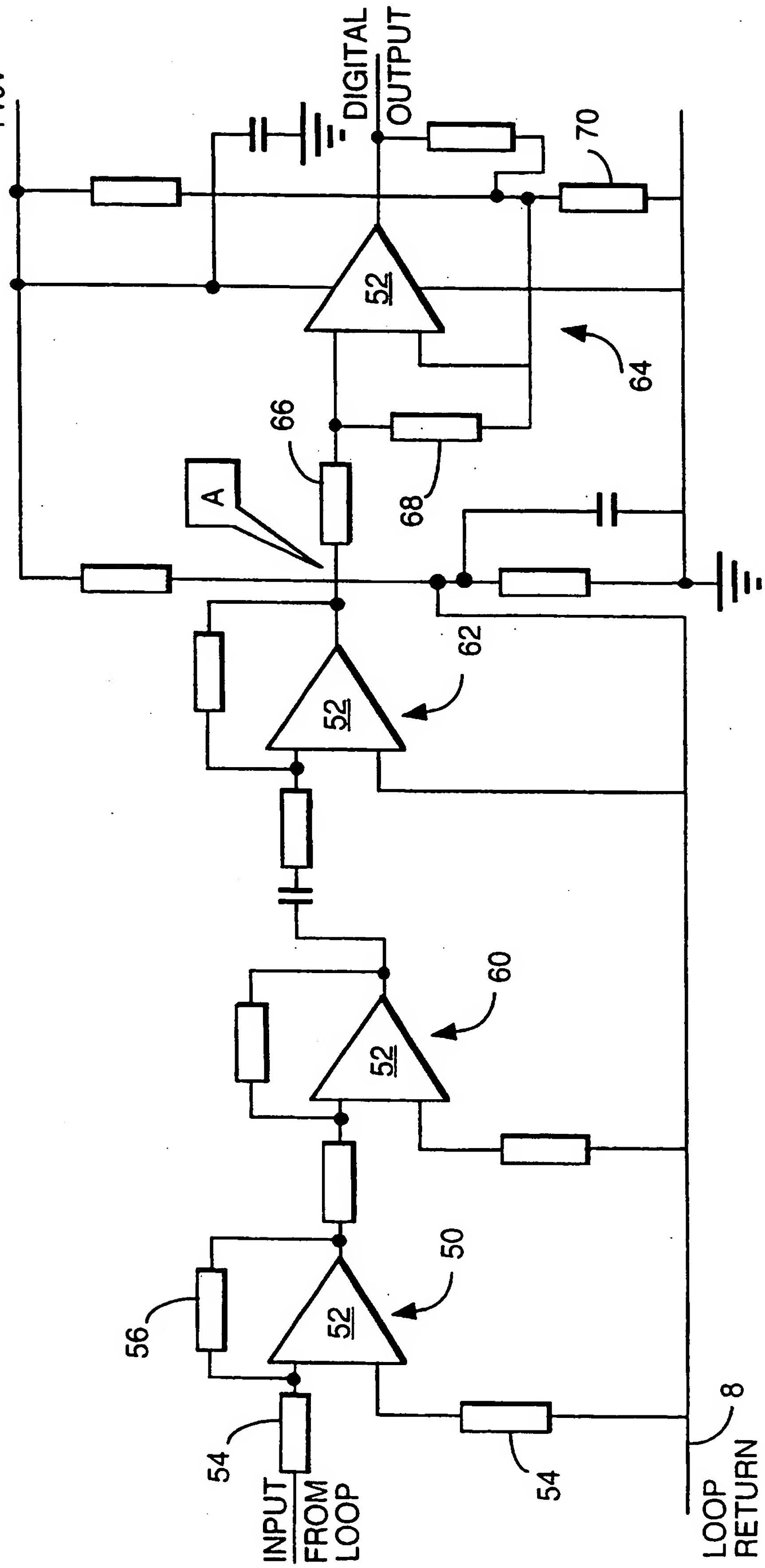

+10v
DIGITAL
OUTPUT
70
52
64
66
A
68
62
52
60
52
56
50
52
54
INPUT
FROM
LOOP
54
8
LOOP
RETURN

Fig.2A.

Fig.2B.

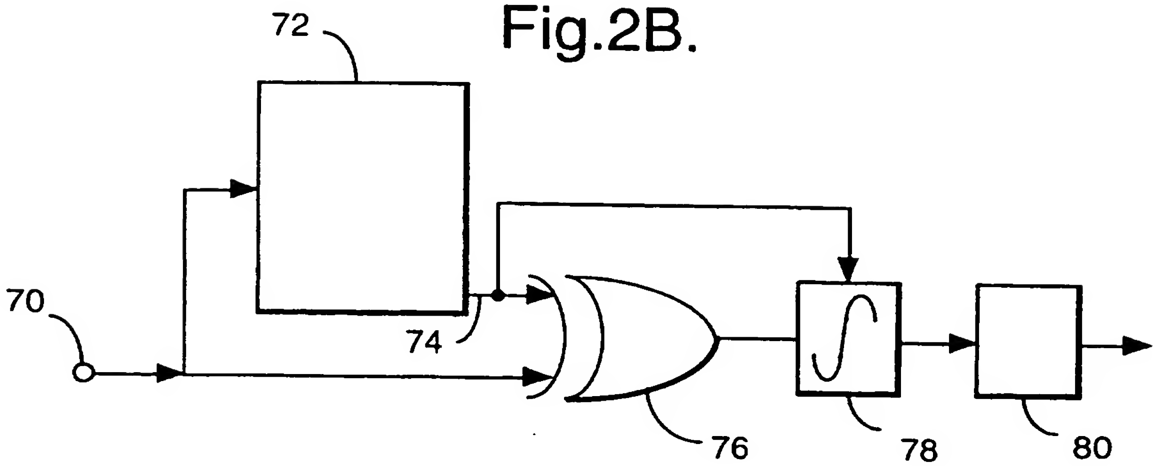


Fig.6.

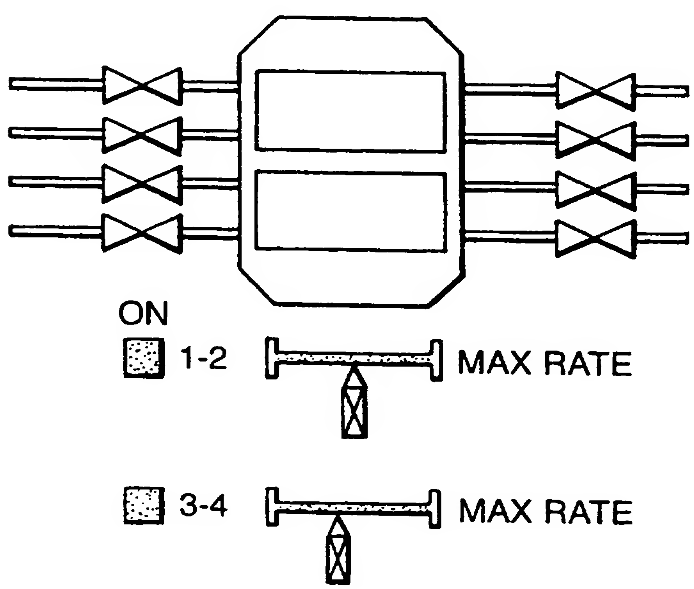
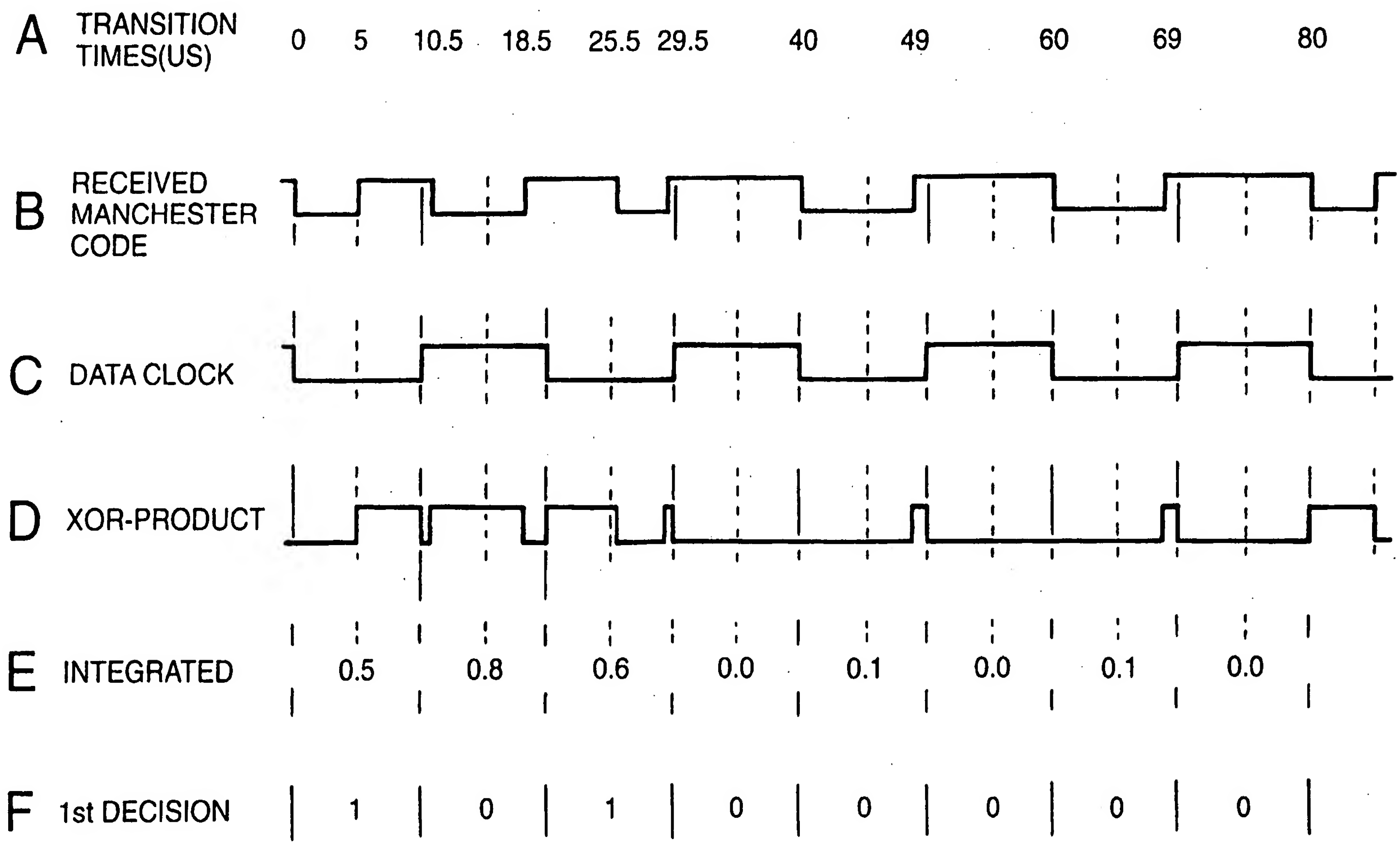


Fig.3.


A TRANSITION TIMES(US)
0 5 10.5 18.5 25.5 29.5 40 49 60 69 80
B RECEIVED MANCHESTER CODE
C DATA CLOCK
D XOR-PRODUCT
E INTEGRATED
0.5 0.8 0.6 0.0 0.1 0.0 0.1 0.0
F 1st DECISION
1 0 1 0 0 0 0 0

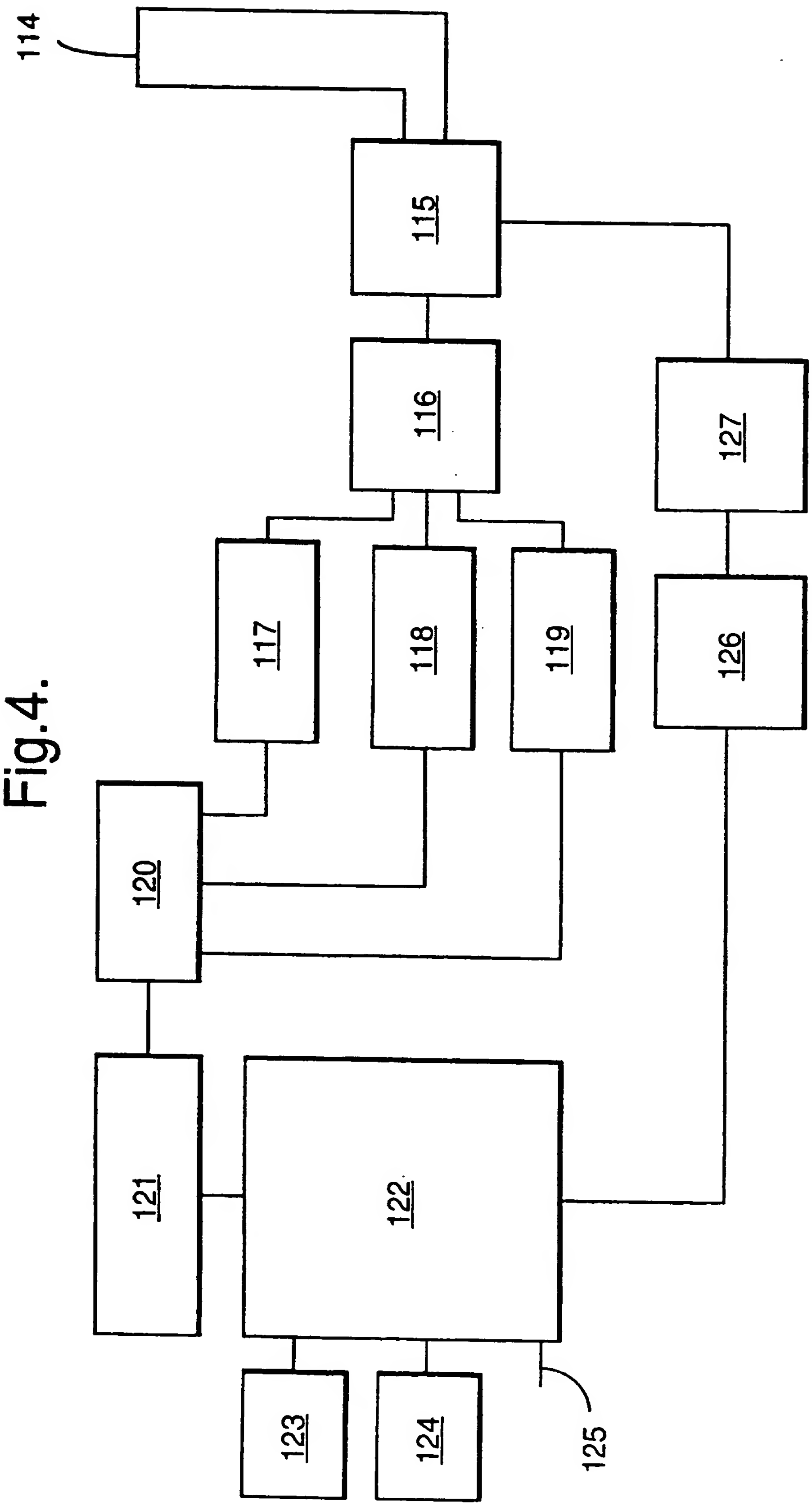


Fig.4.

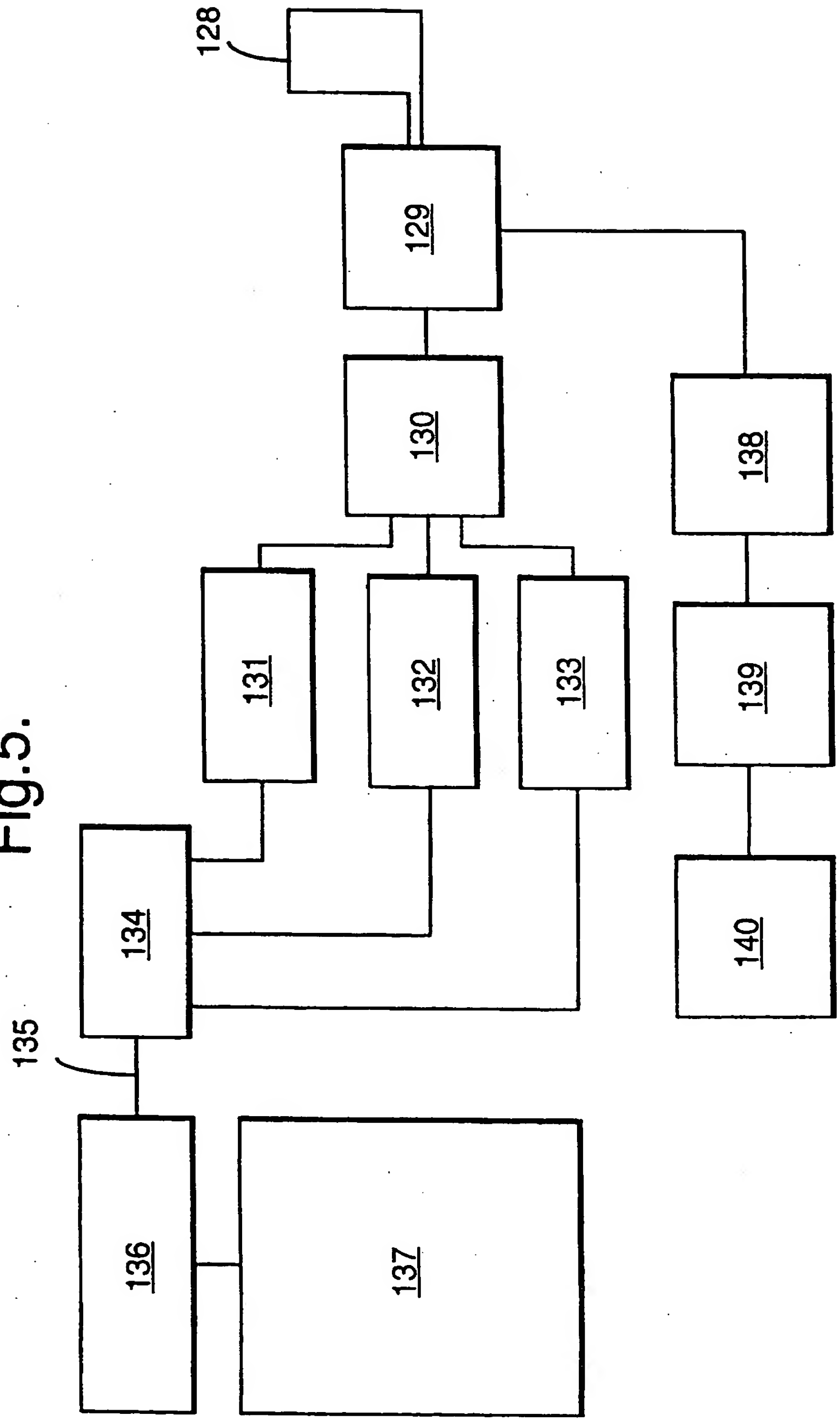
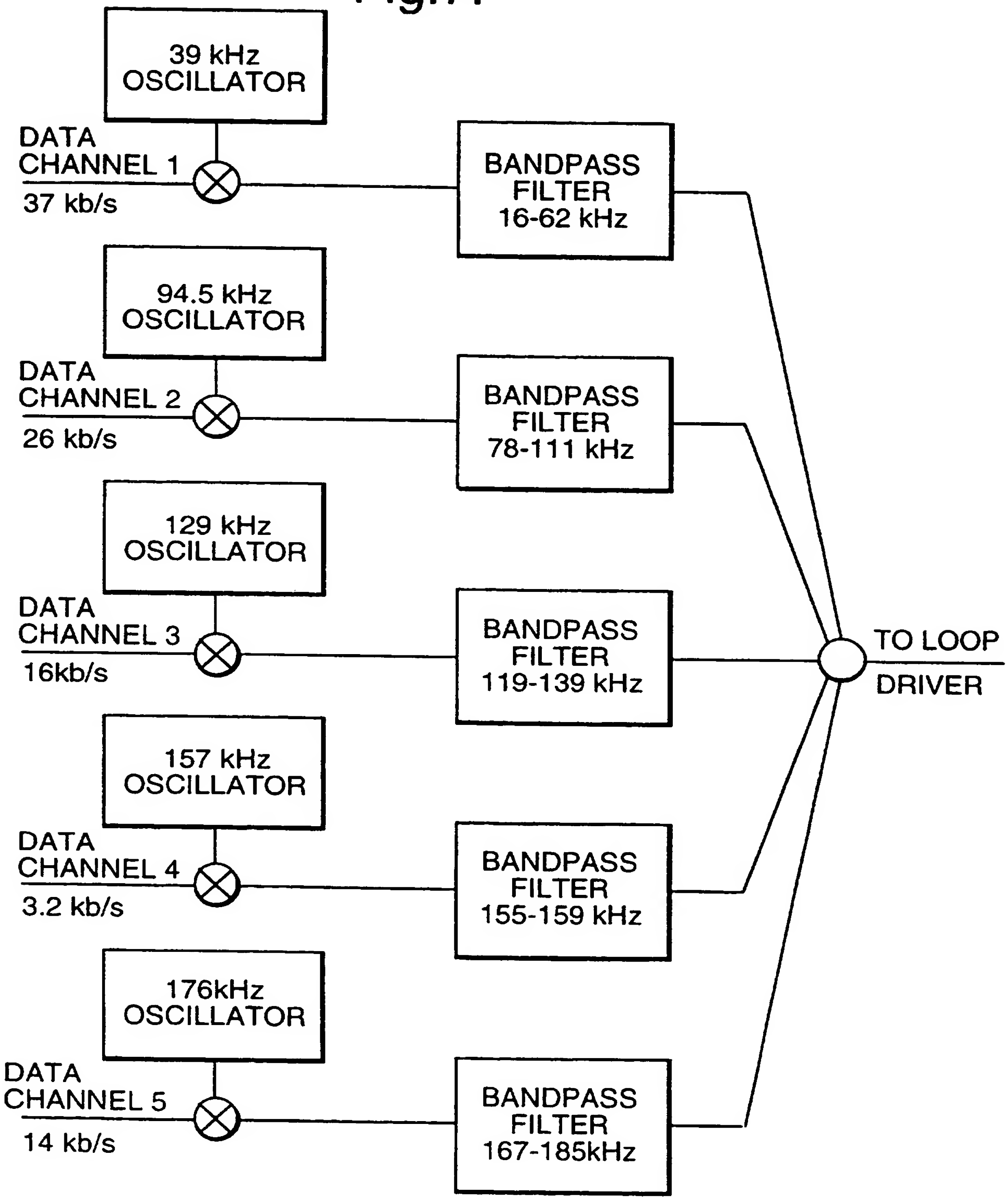


Fig.5.

Fig.7.


39 kHz OSCILLATOR
DATA CHANNEL 1
37 kb/s
BANDPASS FILTER 16-62 kHz
94.5 kHz OSCILLATOR
DATA CHANNEL 2
26 kb/s
BANDPASS FILTER 78-111 kHz
129 kHz OSCILLATOR
DATA CHANNEL 3
16kb/s
BANDPASS FILTER 119-139 kHz
157 kHz OSCILLATOR
DATA CHANNEL 4
3.2 kb/s
BANDPASS FILTER 155-159 kHz
176kHz OSCILLATOR
DATA CHANNEL 5
14 kb/s
BANDPASS FILTER 167-185kHz
TO LOOP
DRIVER

DATA COMMUNICATION SYSTEM

The present invention relates to a data communication system. It relates particularly, though not exclusively, to such a system for communicating over local areas of the order of 100 metre radius.

There is a requirement in many areas such as in industrial, home and office applications, for a low cost method of communicating data from a number of stations and one or more central locations within a building for example. Systems which employ coaxial feeder lines are inherently expensive. Furthermore such systems commonly operate in the Megahertz and Gigahertz regions, which implies a relatively high cost of transmission and reception circuitry at each node (station) of the system.

One known type of system which has been used is known as a "leaky feeder" in which an evanescent field transmitted from a coaxial cable or twisted pair line is used as the communication medium for a number of nodes positioned around a building for example. An advantage of such a system is that the very short range of the evanescent field reduces interference problems with other equipment generating RF radiation, but since such systems commonly operate at Gigahertz frequencies, the cost of the transmitting/receiving circuitry in each node is relatively high.

Another type of system is described in US-A- 4,937,586 in which information is disseminated to shelves for goods in retail stores by means of a low frequency (132 kHz) signal which is radiated from an inductive loop. Although the use of a single wire inductive loop reduces costs, the disadvantage of the described system is that the bandwidth of the transmitted information is relatively low (1500 baud), the system employing highly tuned equipment. This obviously limits the amount of information that can be transmitted through the system.

According to a first aspect of the invention, there is provided a communication system including a transmitter and receiver, the transmitter being adapted to transmit radio frequency signals in the frequency range 0 - 500 kHz with a wide bandwidth of at least 10 kHz, preferably between 50 kHz and 200 kHz, at least one of the transmitter and receiver having an inductive loop antenna whose impedance is mainly or solely in the form of an inductive reactance, and wherein the frequency characteristics of the transmitter and receiver are such that the wide bandwidth signals can be transmitted and received without significant signal degradation arising from changes in frequency response. Such a communication system can provide a system for communicating with a multiplicity of nodes over local areas and having the capability of transmitting large quantities of

information over a large bandwidth using low cost apparatus. A further advantage is that such a system does not require a broadcast licence in the UK.

In a more specific aspect, the present invention provides a transmitter for a communication system, the transmitter being adapted to transmit radio frequency signals in the frequency range 0 - 500 kHz with a wide bandwidth of at least 10 kHz, preferably between 50 kHz and 200 kHz, the transmitter including an inductive loop antenna whose impedance is mainly or solely in the form of an inductive reactance, wherein the frequency function of the transmitter is such that there is no significant frequency dependent change in the transmission function over the frequency band of the wide bandwidth signals.

In a further specific aspect, the present invention provides a receiver for a communication system, the receiver being adapted to receive radio frequency signals in the frequency range 0 - 500 kHz with a wide bandwidth of at least 10 kHz, preferably between 50 kHz and 200 kHz, the receiver including an inductive loop antenna whose impedance is mainly or solely in the form of an inductive reactance, wherein the frequency response function of the receiver is such that over the bandwidth of the wide bandwidth signals, there is no significant frequency dependent change in the frequency response function.

Thus in accordance with the invention wide bandwidth signals, for example compressed video data signals having a bandwidth of 100 kHz, may be transmitted and received over a low power short range inductive communication system. In view of the low power and short range, there is little significant risk of interference with other transmissions from other communication systems, such as nearby computer networks. Further at such low frequencies and low powers, some Jurisdictions, in particular the UK, may not require a legal license for operation of the apparatus.

Good signal strengths may be received for loops of 100 metre radius at distances of typically 200 metres from the centre of the loop. Such distances are of the order of magnitude of the size of a large building or factory site. Thus the system according to the invention may be employed in many applications in the office or factory, e.g. in computer networks for transmitting text data or control data to a central station, in process control where telemetry data or video information from stations in the process equipment are routed to a central control console, or in the home where video and control information for equipment used in the home are routed to or from central location. Thus the inductive loop will be routed around the perimeter of the home, office or factory.

Although it is envisaged that the system of the invention has use primarily over local areas of the order of 100 metre radius, it is possible to employ the invention over much larger areas, for example of the order of kilometres or even tens of kilometres, or in much smaller areas, of the order of metres.

Where video signals are transmitted, e.g. in a process control application of a crucial item of equipment, there are well known methods of data compression (e.g. MPEG algorithm) for video signals which will permit compression to 100 kHz whilst still giving an acceptable image for industrial purposes. Where a number of cameras are employed giving different images, frequency or time multiplexing methods may be employed to transmit all the images to the central station.

According to a further aspect of the invention there is provided a method of communicating video information from a source to a display means, the method comprising a) compressing the video information into signals in the frequency range 0 kHz to 500 k Hz, b) loading the signals onto an induction loop, c) sensing the signals by induction using a receiving antenna, d) decompressing the video information from the signals, and d) displaying the video information.

The present invention is based on the realisation that wide bandwidth data signals may be transmitted using relatively low cost equipment using a mode of radio frequency transmission known as low power induction communication. Such low power induction communication normally involves transmission on frequencies between 0 and 500 kHz employing transmission powers of up to about 10 watts. Such systems commonly employ inductive loop antennas; a significant feature of such antennas is their small effective range of operation, of the order of metres or hundreds of metres. This is because the primary operative field is an inductive field which falls off very rapidly with distance; in contrast, the long range propagating electromagnetic wave field which is generated is not significant in power.

Furthermore, the invention is based on the realisation that such low frequency induction systems may be adapted to carry wide band data signals for example compressed video data signals. For the purposes of this specification, wide band data signals include any signals having a band width greater than 10 kHz, preferably band widths of the order of 100 kHz, say between 50 kHz and 200 kHz. It is thus a feature of the invention to provide a low power induction communication system with a transmission frequency response which modifies the frequency response of an inductive loop such that wide band data signals may be transmitted and received without significant signal degradation.

To permit wide band communication, it will firstly be noted that the inductive reactance of an inductive loop will normally be a linear function of frequency and hence the low frequency end of a wide bandwidth signal will experience different transmission parameters to that of the high frequency end. In one embodiment, a resistance is inserted is

inserted in the output circuit of the transmitter in series with the inductive loop and of such value that the inductive reactance of the loop is small compared with the resistance, for example the resistance is of the order of 10 times the value of the inductance. This effectively provides a constant current source and the output magnetic field is constant. In an alternative embodiment, a constant current source is employed coupled to the inductive loop which since it has in theory an infinite output impedance, will provide a constant output magnetic field strength. In view of the low powers involved, commonly less than 10 watts, it is possible to insert large value resistive impedances into a transmission loop without causing excessive power dissipation.

For an inductive loop coupled to a receive circuit, the magnetic field induces a voltage which is proportional to the rate of change of magnetic flux, i.e. frequency. Hence the voltage output from the receiving loop is proportional to frequency. However, the receiving loop has inductance. In a preferred embodiment, the receiving loop is short-circuited or loaded into a sufficiently low resistance that the resistance may be ignored, and hence the impedance of the loop amount to the inductive impedance and is directly proportional to frequency. Thus the received current, proportional to received voltage divided by input impedance, will be independent of frequency, so that a flat frequency response is provided.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which :-

Figure 1 shows a diagram of a first embodiment of apparatus according to the invention;
Figures 2a and 2 b show a schematic diagram of one form of the receiver of Fig. 1;
Figure 3 is an example, in graphical form, of the decoding of received data;
Figure 4 is a block schematic diagram of a further form of transmitter for the invention;
Figure 5 is a block schematic diagram of a further form of receiver for the invention;
Figure 6 is an example of a screen of computer graphics data which for use in the present invention; and

Figure 7 is an example of a frequency multiplexing scheme for multiplexing various channels of data on to a single loop driver.

Referring now to the drawings, Figure 1 shows a transmitter 2, adapted to transmit on a frequency range between 0 and 185 kHz, coupled to a single strand cable loop 4 which is 60 metres long by 30 metres wide. Loop 4 is routed around the perimeter of a building in which are located a number of work stations 6_n. Each work station includes video images. Such work stations may be personal computers coupled to receive multi-media information

which includes data in addition to video information. Each work station 6 includes a receiver loop antenna 8 comprising 26 turns of wire with a diameter of 6 centimetres and an inductance of 110 microhenries; it is positioned one metre away from the inside of the loop.

The inductance of loop 4 is about 500 μH and its series resistance is about 10 ohms. The transmitter output impedance is 600 ohms, much greater than the reactive impedance of the loop. The transmitter provides 300 V peak voltage output and an output current of 0.5 Amps.

Each receiver comprises a receiver amplifier 10, a data slicer 12 and an output circuit 14.

In Figure 1, an output stage 10 of transmitter 2 is shown comprising a bridge circuit of two current paths 12, 14 connected between a positive rail 16 of plus 300 V and a negative rail 18 of minus 300 V. Each current path 12, 14 contains a P-type power MOSFET 20 and a N-type MOSFET 22 (for example, the commercially available transistors MTP2N50 and MTP2P50). Nodal points 24 between transistors 20, 22 are coupled to a transmitter output comprising a balance low pass filter 26 for removing transmitter harmonics and a resistive output impedance of 600 ohms comprised of four separate resistors 28 and 150 ohms connected as shown between nodal points 24 and filter 26 and between filter 26 and output terminals 30. The inductive loop 4 is directly connected to output terminals 30. In addition, in the output stage, decoupling capacitors and electrostatic voltage protection are provided (not shown). Preceding stages of the transmitter (not shown) supply data signals for transmission to the gates Vin of transistors 20, 22 in the form shown in row B of Figures 3, namely a Bi-Phase-Mark data code wherein a transition occurs at the beginning of every symbol period, the value one being represented by a second transition one half period later, and the value 0 being represented by no second transmission. This data is transmitted without a carrier (i.e. a DC carrier), so that the maximum modulation frequency is 185 kHz, with a symbol period of about 10 micro seconds.

The system illustrated in Figure 1 is constructed with a view to conforming to UK MPT 1337 Performance Specification issued by the UK Department of Trade and Industry June 1988 for low power induction communications and control systems operating in the frequency bands 0 to 185 kHz and 240 kHz. In particular the power which would be dissipated to a dummy antenna comprising a 300μH inductor in series with a 4.7 ohm resistor is less than 10 W. It will be understood that some adaptation of the circuit may be necessary for strict compliance with this Standard. It will be understood that official requirements for such systems may vary from jurisdiction to jurisdiction, and that the system illustrated may require adaptation to conform to such requirements.

Each workstation 6_n in Figure 1 comprises a receiver preamplifier stage 40 coupled to the receive loop antenna 8, a data recovery circuit 42, and a data user device 44. Figures 2 and 3 show the amplifier stage 40 and the data recovery circuit 42 in more detail.

Referring now to Figure 2a and 2b, and input stage 50 of the receiver amplifier comprises an operational amplifier 52 having both inverting and non-inverting inputs connected through respective 50 ohms resistances 54 to the receive loop 8, and with a feedback resistor 56 of 1.5 k ohms connected between the output and the non-inverting input. This provides an input impedance of 50 ohms which is to be compared with the inductive reactance of the loop 8 at 200 kHz of 120 ohms. The input impedance is sufficiently small to give a flat frequency response for the preamplifier over the frequency range of 0 - 200 kHz. If desired, the input impedance may be made arbitrarily small by connecting a small value resistor, for example 5 ohms, across the loop terminals at the input to preamplifier circuit 50 for increasing the frequency range over which the response is flat.

The output of preamplifier stage 50 is connected to first and second amplifier stages 60, 62 each having an operational amplifier 52. The output of stage 62 is connected to a threshold limiting circuit 64 which functions to provide a digital output with fixed positive and negative peak values. To this end, the threshold circuit 64 has an operational amplifier 52 with a 10K ohms input resistor 66 connected to the non-inverting input of amplifier 52, and a 330 k ohms resistor 68 connected across the non-inverting and inverting inputs. The inverting input of the amplifier is held at a fixed potential by means of a voltage divider circuit 70.

The output from threshold circuit 64 is applied to an input 70 of the circuit shown in Figure 2b in which a data clock 72 comprising a phase locked loop circuit, phase locked to input signal 70 provides a data clock signal on line 74 which is compared with input signal on line 70 in an exclusive or circuit 76; these signals are indicated in rows B, C and D of Figure 3. The output of exclusive or circuit 76 is integrated at integrator circuit 78 over a bit period and the integration value, indicated in row E of Figure 4 is applied to a Bit Decision circuit 80 comprising threshold circuits (not shown) which decide whether the bit is a one or zero depending on whether the integrated value is at a mid-range value or at an upper or lower range value.

At this point, the data is fully recovered and may be fully applied to data use circuit 30. The data may for example represent graphics primitives such as "CIRCLE 100,50". Such graphics primitives inherently compress data. The representation in Figure 6 is that of graphics primitives which require only a relatively small amount of data to display. The representation of Figure 6 uses about 2000 bytes of information. Alternatively, a screen of text may be displayed, requiring about 1000 characters for a full screen update.

Alternatively, a screen of graphics may be generated by addressing individual pixels. In multi-media designs, a bit map graphic image or animated video display may be a smaller area than the full screen. The total amount of data for a bit map screen display is of the order of 1000 bytes, and data compression by a factor of 10 or 20 would produce an acceptable quality image. The data may for example represent a compressed video signal or graphics file or bit map or image according to the MPEG or JPEG algorithms, the data being presented through appropriate display circuitry to a display screen.

These considerations are shown in the table below where the type of image is listed with accompanying data parameters.

Image Type	Size	Data [bytes]	Data [bits]	Data Rate [kb/s]	Image Update rate [images/s]
Text(menu)	40c x 24r	960	7680	100	13
Graphics Metafile	N/A	2062	16496	100	6.1
Bitmap	320 x 240 pixels	76800	614400	100	0.16
Bitmap (compressed 20:1)	320 x 240 pixels	3840	30720	100	3.3

Table 1

Preferred Band	Width [kHz]	Data Rate [kb/s]
16-62 kHz	46	37
78-111 kHz	33	26
119-139 kHz	20	16
155-159 kHz	4	3.2
167-185 kHz	18	14

Table 2

Figure 4 shows a transmitter according to the invention in the form of a "base station" together with a source of signals. In this example the base station also comprises a receiver to enable two way communication with a portable receiver unit (not shown in this figure, but as shown, for example, in Figure 5 including a further transmitter transmitting in the 240 - 315 kHz frequency range. This Figure shows a transmitter 116 having an output

in the form of an induction loop 114. The transmitter operates in the 0 kHz to 185 kHz frequency range. The induction loop is also coupled via a diplexer 115 to a receiver 127 operating in the 240 kHz to 315 kHz frequency range. The transmitter is fed video information from closed circuit television cameras 123 and 124 and from a satellite link 125. The information passes through a camera control and switching system 122, and the information is then compressed by a video compression system 121. The information is then fed to a demultiplexer which separated the compressed information into three separate data streams or sub-bands which are then each modulated onto carrier waves of respective different frequencies by data modulators 117, 118 and 119. This compressed, demultiplexed and separately modulated video information is then fed to the transmitter 116 which provides these signals to the induction loop. The receiver 127 has its output connected to a control system 126 which communicates control signals sent from portable units close to the loop to the camera controller 122 to enable one possible signal source to be swapped for another. The separate sub-bands are positioned in the frequency spectrum to avoid the most troublesome sources of interference in the frequency range 0 kHz to 185 kHz in the locality of the loop.

Figure 5 shows a block diagram of a portable receiver in the form of a handset for use within or near the base station induction loop to receive signals from the transmitter described above. The receiver is largely the reverse of the base station unit. The signals are sensed by a coil antenna 128, and are then directed to the receiver 130 through a diplexer 129. The receiver operates in the frequency range 0 kHz to 185 kHz. The three modulated video sub bands are then demodulated by demodulators 131, 132 and 133, and then combined by a multiplexer 134 to reconstruct the compressed video information. The data multiplexer has an output 135 which is coupled to a video decompression system 136. the decompressed video information is then displayed using a video display unit 137, comprising in the present example an LCD.

The receiver of Figure 5 also comprises a transmitter 138, which is coupled to the coil antenna 128 via the diplexer 129. This transmitter operates in the frequency range 240 kHz to 315 kHz for communication with the base station transmitter described above. In the present example the transmitter transmits control signals generated from a keypad 140 located on the handset. The signals are encoded by an encoder 139 before transmission.

In the present example, an MPEG standard algorithm is used to compress the information in the transmitter and to decompress the signals in the receiver.

The circumstances in which the inductive communications band might need to be divided up into sub-bands are either where separate sub-bands are required to allow independent communications systems to operate simultaneously, or when there are

significant interference signals present in-band, such as when using an inductive loop system for maximum range performance with very weak received signals. Data rates are shown in Table corresponding to the signalling speed obtainable for BPSK modulation (0.8 times IF bandwidth); other forms of modulation may allow higher signalling speeds for a given bandwidth, for example 16-ary APK (3.1 times IF bandwidth) would allow 3.9 times the data rate compared to BPSK for the same bandwidth.

In order to transmit compressed video signals, the apparatus must have a sufficiently wide bandwidth response. An example of how this may be achieved is shown in the embodiment of Figure 2. A resistance 8 is connected in series between the signal source 9 and the transmitting loop 10. The receiver comprises an operational transconductance amplifier 12 connected between a receiving loop antenna 11 and the rest of the receiver circuit 13.

As an alternative to the apparatus shown in Figure 2, the use of a controlled 50 or 75 ohm impedance source and a 50 ohm input amplifier between the antenna and the rest of the receiver may also provide a sufficiently flat frequency response. A low impedance input amplifier may be used in place of the operational transconductance amplifier shown in Figure 2. The use of known techniques to boost signal strength such as tuning capacitors or self-resonant loops, or impedance matching networks are not feasible if a wide bandwidth response is to be achieved. In the present invention sufficient signal strength is obtained using untuned loops and a low noise input amplifier at the receiver.

Figure 3 shows a transmitter according to the invention in the form of a "base station" together with a source of signals. In this example the base station also comprises a receiver to enable two way communication with a portable receiver unit (not shown in this figure, but as shown, for example, in Figure 4) including a further transmitter transmitting in the 240 - 315 kHz frequency range. This Figure shows a transmitter 16 having an output in the form of an induction loop 14. The transmitter operates in the 0 kHz to 185 kHz frequency range. The induction loop is also coupled via a diplexer 15 to a receiver 27 operating in the 240 kHz to 315 kHz frequency range. The transmitter is fed video information from closed circuit television cameras 23 and 24 and from a satellite link 25. The information passes through a camera control and switching system 22, and the information is then compressed by a video compression system 21. The information is then fed to a demultiplexer which separated the compressed information into three separate data streams or sub-bands which are then each modulated onto carrier waves of respective different frequencies by data modulators 17, 18 and 19. This compressed, demultiplexed and separately modulated video information is then fed to the transmitter 16 which provides these signals to the induction loop. The receiver 27 has its output connected to a control

system 26 which communicates control signals sent from portable units close to the loop to the camera controller 22 to enable one possible signal source to be swapped for another. The separate sub-bands are positioned in the frequency spectrum to avoid the most troublesome sources of interference in the frequency range 0 kHz to 185 kHz in the locality of the loop.

Figure 4 shows a block diagram of a portable receiver in the form of a handset for use within or near the base station induction loop to receive signals from the transmitter described above. The receiver is largely the reverse of the base station unit. The signals are sensed by a coil antenna 28, and are then directed to the receiver 30 through a diplexer 29. The receiver operates in the frequency range 0 kHz to 185 kHz. The three modulated video sub bands are then demodulated by demodulators 31, 32 and 33, and then combined by a multiplexer 34 to reconstruct the compressed video information. The data multiplexer has an output 35 which is coupled to a video decompression system 36. The decompressed video information is then displayed using a video display unit 37, comprising in the present example an LCD.

The receiver of Figure 4 also comprises a transmitter 38, which is coupled to the coil antenna 28 via the diplexer 29. This transmitter operates in the frequency range 240 kHz to 315 kHz for communication with the base station transmitter described above. In the present example the transmitter transmits control signals generated from a keypad 40 located on the handset. These signals are encoded by an encoder 39 before transmission.

In the present example, an MPEG standard algorithm is used to compress the information in the transmitter and to decompress the signals in the receiver.

The circumstances in which the inductive communications band might need to be divided up into sub-bands are either where separate sub-bands are required to allow independent communications systems to operate simultaneously, or when there are significant interference signals present in-band, such as when using an inductive loop system for maximum range performance with very weak received signals. Data rates are shown in Table 2 corresponding to the signalling speed obtainable for BPSK modulation (0.8 times IF bandwidth); other forms of modulation may allow higher signalling speeds for a given bandwidth, for example 16-ary APK (3.1 times IF bandwidth) would allow 3.9 times the data rate compared to BPSK for the same bandwidth.

It will be found in many modern office buildings that low frequency interference from computers and computer networks predominates over the above bands, and local conditions will vary from site to site. Consequently an adaptive system may be able to allocate sub-bands which are optimum for a specific site. Figure 7 shows an example of a modulation system where data in 5 channels is modulated on to separate sub-bands, using a BPSK modulator, and with bandpass filters removing out-of-band sidelobes. The use of

many other modulation techniques may be contemplated, but particularly ASK, PSK, OOK, FSK, MSK, GMSK, may be useful.

The modulation system may be implemented numerically using digital signal processing (DSP) techniques, equivalent to the analogue techniques but using numerical operations to manipulate the signal in the time and frequency domains with the signal being represented by binary numbers. The use of DSP is particularly attractive from the viewpoint of being able to divide a signal up into arbitrary sub-bands without the need for hardware filters. The sub-bands may be selected adaptively to cater for local conditions. For example, the inductive loop band might be divided into a large number of identical width sub-bands, which are then monitored for interference, then the signal processor selects the most interference-free sub-bands and routes the data via these selected sub-bands. The process of splitting a data signal into many sub-bands is illustrated by a known technique used in Digital Audio Broadcasting (See BBC Information Sheet 1057(2)9210) which uses the Inverse Fourier Transform to generate a waveform in the communications channel that is combined from many inputs applied to each of the frequency channels that are inputs to the transform. Each input signal generates energy in a specific frequency band in the communications channel. If sufficient signal to noise ratio is available, more complex modulation methods may be used on each frequency channel or sub-carrier, i.e. by using an amplitude-phase constellation to select multiple bits per symbol, Monnier et. al (Digital Television Broadcasting with High Spectral Efficiency, R. Monnier, J. B. Rault, T. de Couasnon, International Broadcasting Convention, Amsterdam, July 1992) have demonstrated a system in which 34 Mb/s may be sent over an 8MHz channel; so with the same 64QAM, 512 sub-carrier OFDM system but scaled to use a 16 kHz to 185 kHz bandwidth, a bit rate of 718kb/s could be achieved. As the cost of DSP comes down, the use of modulation techniques such as this will become more attractive for low cost inductive loop communications systems and will support very useful bit rates.

Finally, the priority document for the present application (including the accompanying diagrams and abstract), reference number GB 9605335.0, is incorporated herein by reference

CLAIMS

1. A communication system including a transmitter and receiver, the transmitter being adapted to transit radio frequency signals in the frequency range 0 - 500 kHz with a wide bandwidth of at least 10 kHz, at least one of the transmitter and receiver having an inductive loop antenna whose impedance is mainly or solely in the form of an inductive reactance, and wherein the frequency characteristics of the transmitter and/or receiver are such that the wide bandwidth signals can be transmitted and received without significant signal degradation arising from changes in frequency response.
2. A transmitter for a communication system, the transmitter being adapted to transmit radio frequency signals in the frequency range 0 - 500 kHz with a wide bandwidth of at least 10 kHz, the transmitter including an inductive loop antenna whose impedance is mainly or solely in the form of an inductive reactance, wherein the frequency function of the transmitter is such that there is no significant frequency dependent change in the transmission function over the frequency band of the wide bandwidth signals.
3. A receiver for a communication system, the receiver being adapted to receive radio frequency signals in the frequency range 0 - 500 kHz with a wide bandwidth of at least 10 kHz, the receiver including an inductive loop antenna whose impedance is mainly or solely in the form of an inductive reactance, wherein the frequency response function of the receiver is such that over the bandwidth of the wide bandwidth signals, there is no significant frequency dependent change in the frequency response function.
4. A system, transmitter or receiver according to any of claims 1 to 3 wherein said bandwidth is between 50 kHz and 200 kHz.
5. A system, transmitter or receiver of any preceding claim wherein the diameter of the loop antenna is between 1 metre and 500 metres.
6. A system or transmitter according to claim 1 or 2, wherein the transmitter has a resistive output impedance which is substantially greater than the inductive impedance of the loop antenna over the range of transmitter frequencies, preferably more than ten times as great.
7. A system or transmitter according to claim 6 wherein the resistive output impedance is located within the transmitter or is externally connected between the transmitter and the loop antenna.
8. A system or transmitter according to claim 1, 2, 6 or 7 wherein the output stage of the transmitter comprises P and N type power MOSFETS connected in a bridge configuration.

9. A system or transmitter according to claim 8 in which the said output stage comprises a first current path including the main current paths of a P type and N type MOSFET, a second current path including the main current paths of a further P type and N type MOSFET, and the output of the transmitter is coupled to nodal points between the MOSFETs in the first and second current paths.

10. A system or transmitter according to claim 9 including a resistor means and a band pass filter is connected between the output part and the nodal parts.

11. A system or receiver according to claim 1 or 3 wherein the receiver includes a preamplifier comprising an operational amplifier with resistive means connected between the antenna and the operational amplifier for defining the input impedance of the receiver.

12. A system or receiver according to claim 11 wherein the receiver includes data recovery means including a first threshold means for defining the input signal between first and second threshold levels, data clock means, and a gating means having as inputs the clock signal and the input signal, means for integrating the output of the gate means over a bit period, and means for decoding the output of the integrating means to provide recovered data to a data utilisation device.

13. A system, transmitter or receiver according to any preceding claim wherein the transmitted signal has no carrier wave (DC carrier wave).

14. A system, transmitter or receiver according to claim 4 wherein said band width is 100 kHz, and the data represents a video signal.

15. A system or transmitter according to claim 1 or 2 including frequency multiplexing means for modulating wide bandwidth signals from a plurality of sources onto a single carrier.

16. A method of communicating video information from a source to a display means, the method comprising a) compressing the video information into signals in the frequency range 0 kHz to 500 kHz, b) loading the signals onto an induction loop, c) sensing the signals by induction using a receiving antenna, d) decompressing the video information from the signals, and d) displaying the video information.

17. A communication system substantially as described herein with reference to the accompanying diagrammatic drawings.

Amendments to the claims have been filed as follows

1. A method of communicating video information from a source to a display means, the method comprising a) compressing the video information into signals in the frequency range 0 kHz to 500 kHz, b) loading the signals onto an induction loop, c) sensing the signals by induction using a receiving antenna, d) decompressing the video information from the signals, and d) displaying the video information.
2. A video signal communication system for use in the method of claim 1, including a transmitter and receiver, the transmitter being adapted to transit radio frequency signals, representing video information, in the frequency range 0 - 500 kHz with a wide bandwidth of at least 10 kHz, at least one of the transmitter and receiver having an inductive loop antenna whose impedance is mainly or solely in the form of an inductive reactance, and wherein the frequency characteristics of the transmitter and/or receiver are such that the wide bandwidth signals can be transmitted and received without significant signal degradation arising from changes in frequency response.
3. A video signal transmitter, for a video signal communication system as claimed in claim 2, the transmitter being adapted to transmit radio frequency signals, representing video information, in the frequency range 0 - 500 kHz with a wide bandwidth of at least 10 kHz, the transmitter including an inductive loop antenna whose impedance is mainly or solely in the form of an inductive reactance, wherein the frequency function of the transmitter is such that there is no significant frequency dependent change in the transmission function over the frequency band of the wide bandwidth signals.
4. A video signal receiver, for a video signal communication system as claimed in claim 2, the receiver being adapted to receive radio frequency signals, representing video information, in the frequency range 0 - 500 kHz with a wide bandwidth of at least 10 kHz, the receiver including an inductive loop antenna whose impedance is mainly or solely in the form of an inductive reactance, wherein the frequency response function of the receiver is such that over the bandwidth of the wide bandwidth signals, there is no significant frequency dependent change in the frequency response function.
5. A video signal system, transmitter or receiver according to any of claims 2 to 4, wherein said bandwidth is between 50 kHz and 200 kHz.
6. A video signal system, transmitter or receiver acording to any of laims 2 to 5 wherein the diameter of the loop antenna is between 1 metre and 500 metres.
7. A video signal system or transmitter according to claim 2 or 3, wherein the transmitter has a resistive output impedance which is substantially greater than the inductive

impedance of the loop antenna over the range of transmitter frequencies, preferably more than ten times as great.

8. A video signal communication system or transmitter according to claim 7 wherein the resistive output impedance is located within the transmitter or is externally connected between the transmitter and the loop antenna.

9. A video signal communication system or transmitter according to claim 2, 3, 7 or 8 wherein the output stage of the transmitter comprises P and N type power MOSFETS connected in a bridge configuration.

10. A video signal communication system or transmitter according to claim 9 in which the said output stage comprises a first current path including the main current paths of a P type and N type MOSFET, a second current path including the main current paths of a further P type and N type MOSFET, and the output of the transmitter is coupled to nodal points between the MOSFETs in the first and second current paths.

11. A video signal communication system or transmitter according to claim 10 including a resistor means and a band pass filter is connected between the output part and the nodal parts.

12. A video signal communication system or receiver according to claim 2 or 4 wherein the receiver includes a preamplifier comprising an operational amplifier with resistive means connected between the antenna and the operational amplifier for defining the input impedance of the receiver.

13. A video signal communication system or receiver according to claim 12 wherein the receiver includes data recovery means including a first threshold means for defining the input signal between first and second threshold levels, data clock means, and a gating means having as inputs the clock signal and the input signal, means for integrating the output of the gate means over a bit period, and means for decoding the output of the integrating means to provide recovered data to a data utilisation device.

14. A video signal communication system, transmitter or receiver according to any claim 2 to 13 wherein the transmitted signal has no carrier wave (DC carrier wave).

16. A video signal communication system, transmitter or receiver according to claim 6 wherein said band width is 100 kHz.

17. A video signal communication system or transmitter according to claim 2 or 3 including frequency multiplexing means for modulating wide bandwidth signals from a plurality of sources onto a single carrier.

18. A video signal communication system substantially as described herein with reference to the accompanying diagrammatic drawings.

The Patent Office

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Application No: GB 9704347.5
Claims searched: 1-15

Examiner: Nigel Hall
Date of search: 15 April 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4L (LCL); H1Q (QDH)

Int Cl (Ed.6): H04B 5/00

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2048615 A (HIT RECORD)	1-5

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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Application No: GB 9704347.5
Claims searched: 16
Examiner: Nigel Hall
Date of search: 24 June 1997

Patents Act 1977
Further Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4L (LCAX, LCL, LCX)

Int Cl (Ed.6): H04B 5/00, 10/10; H04L 12/28

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2163029 A (RAYNOR)	
A	GB 2048615 A (HIT RECORD)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.